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COMPUTATIONAL ANALYSIS OF UNMANNED AERIAL VEHICLE WING WITH TRIANGULAR WINGLETS

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ABSTRACT

Computational fluid analysis of an aircraft plays an important role in providing a detailed understanding about the particular aircraft. The qualitative and quantitative characterization of the wings provide the necessary information to check the selection of wings and designing of wings prior to time consuming fabrication of aircraft. Standard wing geometry with Eppler E334 series airfoil has been selected for doing a comparative study with the modified models. The lift, drag and lift to drag ratio for each wing models were determined. The comparative study between the modified wing and base wing clearly shows how minute changes could affect the overall aerodynamic characteristics. The models were designed using CATIA V5 software and simulations were done in ANSYS. The analyses were carried out for velocity 20 m/s and for various angles of attack such as 0, 5, 10, 12, 15 degrees. The wing configuration with winglet shows better aerodynamic performance at high angle of attack when compared with without winglet configuration.

KEYWORDS: UAV, Eppler E334, Aerodynamic Performance & Winglets

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INTRODUCTION

The shape and design of the aircraft can dramatically influence the performance and control of the aircraft. The qualities of flight simulation greatly depend on the stability and control derivatives. Wind tunnel testing is a common method for analysis the flow over a body. But the wind tunnel testing is very expensive and it is a time consuming methodology also. Also, the model should be scaled down to get fit inside the tunnel. This could also affect the results because the flow over small body is very much different than the flow over large bodies. Over the past two decades, computer simulation becomes more prevalent because of its vast advantages towards the analysis field. The computational software is user friendly but generation of mesh requires a great experience. These software can be used many times and also many different test cases can be run to determine the flying qualities under various conditions. Cfd Analysis of an Rc Aircraft Wing has done by Shreyas Krishnamurthy, Suraj Jayashankar, Sharath V Rao, and Rochen Krishna T S. In their work, the stated that the computational fluid dynamics (CFD) analysis of an aircraft plays an important role in providing an ideal design of the aircraft. The prior analysis of wing provides useful information to verify the wing selection and design prior to the time consuming while fabricating the aircraft. Designed wing geometry was analyzed and modified; analyses

were continued on the modified wing for a comparative study. This gives a clear comparative knowledge of how minute changes will affect the flow characteristics of the aircraft. The lift coefficient, drag coefficient, stall angle and lift-to-drag ratio values for each wing were determined and the comparative study of these showed how minute changes to the wing improves its overall flow characteristics. Nuno Antfionio Silva had done a work on the optimization of UAV. The aim of their work was to develop and implement a computational process to enable the swift design of divergent UAV configurations and its aerodynamic analysis. During cruise condition, the baseline LEEUAV presents a lift-to-drag ratio of 14.01, stall speed of 6.21 m/s and maximum cruise speed of 29.3 m/s. To enhance the baseline cruise performance, several parametric optimization and sensitivity studies were performed where its nose, wing and fuselage shapes were modified. With the nose shape modification proposal, the adverse pressure gradients that previously existed in that surface were reduced. With rounded wingtips, the wing long laminar separation bubbles were predicted to decrease. With the proposed wing root fairing, a region of separated flow that formed beginning at 2o disappeared thus reducing the aircraft drag. With the proposed wing washout, aileron control effectiveness was extended to angles of attack up to10 degrees. In this study CFD approach for analysis has been selected to understand the aerodynamic characteristics of UAV wing with and without winglets.

MODELLING AND SIMULATION

Development of aircraft design geometry involves deriving geometrical equations of the aircraft. Some parameters such as wing area, sweep angle, taper ratio for each section, chord, span and span wise locations must be determined. These calculated design parameters are then translated into a 3D model using CATIA V5 modelling software. The next stage is the conversion from the three dimensional cad models to CFD model using ICEMCFD software. The third stage is the discretization. The model will be discretized in to the number of nodes. The meshing is also done by using ICEMCFD software. The discretized model was exported to the solver where all the necessary boundary conditions were given to obtain the required results.

The flow characteristics of an aircraft greatly depend on the structure of the wings. The specification of wing chosen is given below.

- Airfoil – Eppler E334
- Semi wing span – 3 m
- Root chord – 0.4 m
- Tip chord – 0.15

The wing is actually rectangular up to semi-span up to 1.8m and later it starts to sweep from 1.8 m and ends with the tip chord of 0.15m. The wing has a dihedral angle of 2.96 degree from the semi span location. The cad model of the base wing and the wing with winglet is shown in figure.

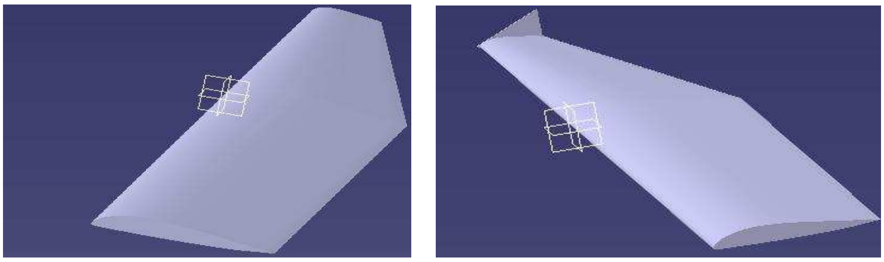


Figure 1: Cad Model of Various Wing Configurations

For discretization unstructured 3D mesh was selected. Unstructured mesh is suitable for the complex structure. For complicated geometries, an unstructured mesh reduces the time consumption in grid generation and improves the accuracy of computation.

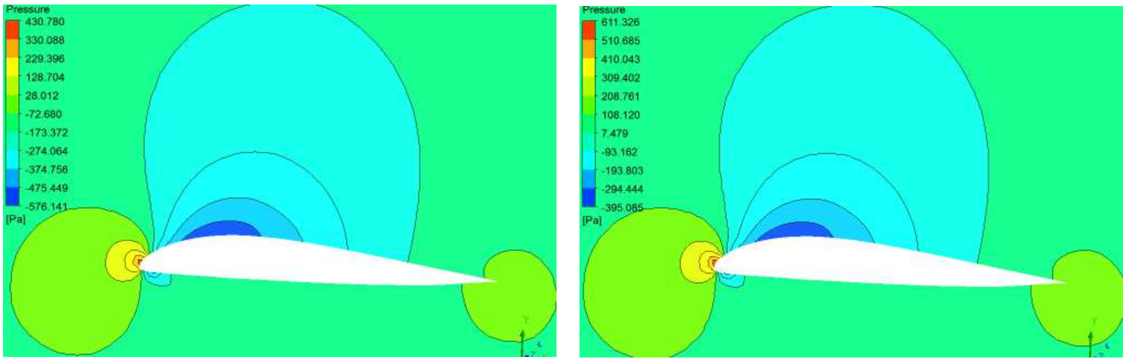
RESULTS AND DISCUSSIONS

The simulations were done using ANSYS CFX software and the modified wing details were compared with the base wing details. The comparative studies majorly focusing on the aerodynamic characteristics of wing which includes drag coefficient lift coefficient and Lift-to-Drag ratio. In addition to these parameters, the pressure contours, temperature contours and velocity contours were also recorded and analyzed for various angles of attack.

Contours

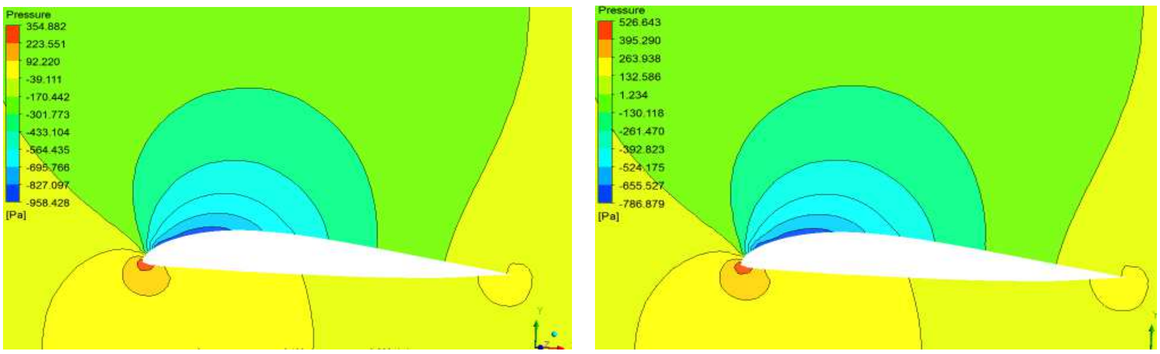
Pressure Contour

Pressure Contour at α=0°



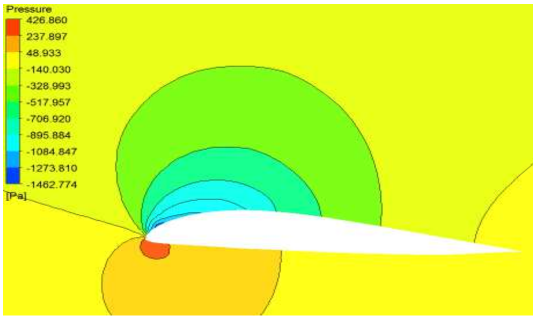
Without Winglet **With Winglet**

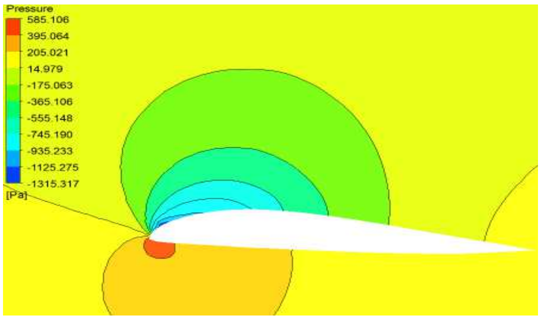
Pressure Contour at α=5°



Without Winglet **With Winglet**

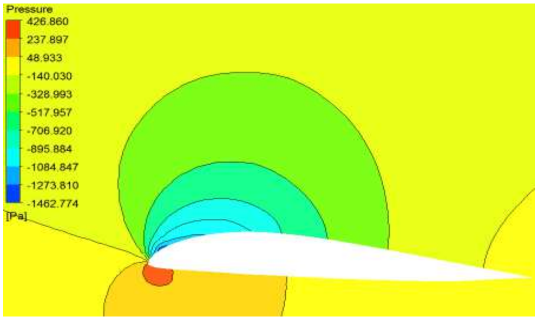
Pressure Contour at α=8°

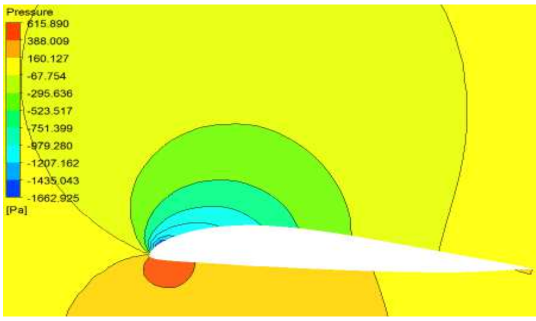




Without Winglet **With Winglet**

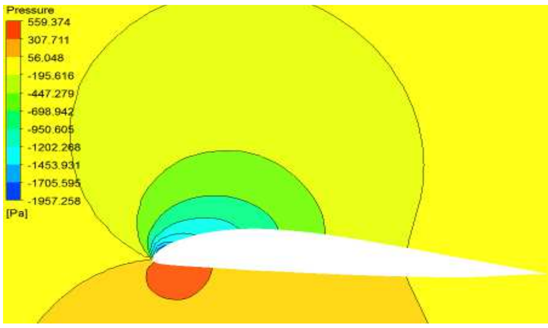
Pressure Contour at α=10°

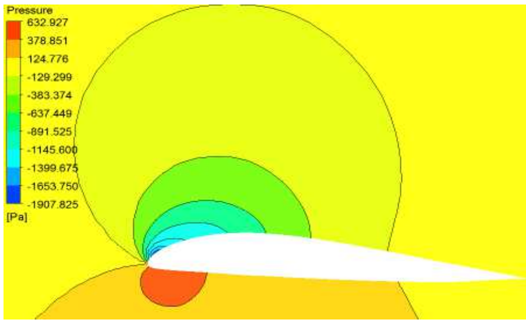




Without Winglet **With Winglet**

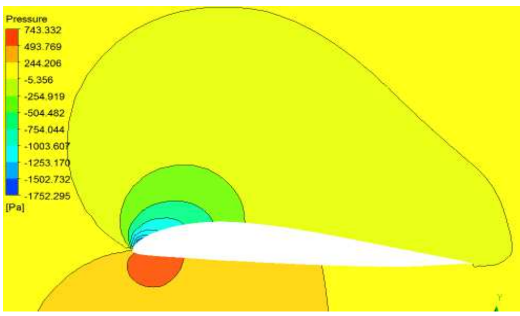
Pressure Contour at α=12°

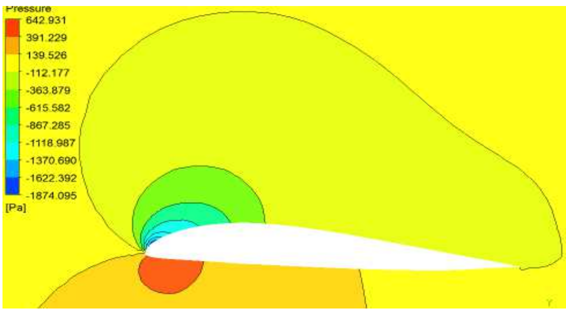




Without Winglet **With Winglet**

Pressure Contour at α=15°



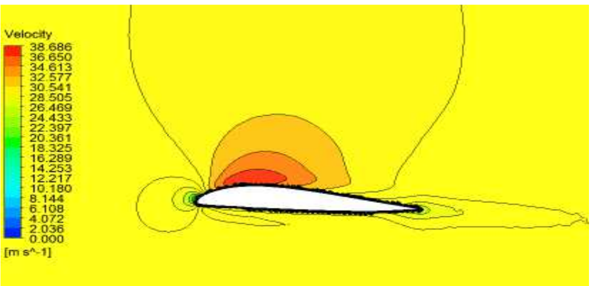


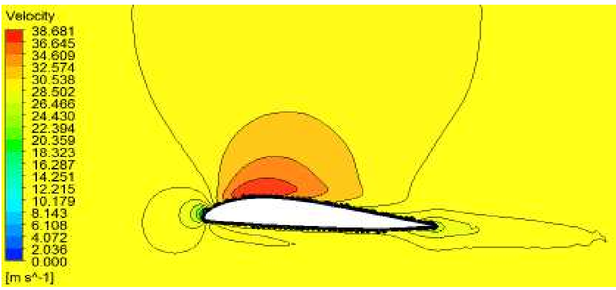
Without Winglet **With Winglet**

Figure 2: Pressure Contour for Different Wing Configuration

Velocity Contours

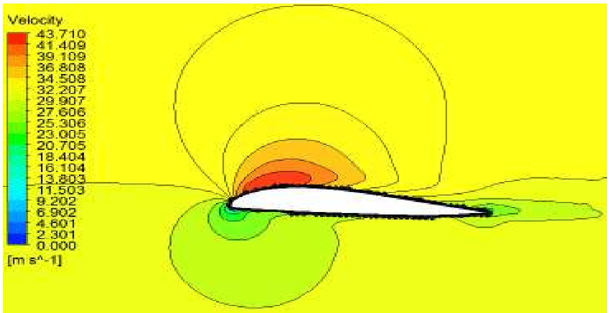
Velocity Contour at α=0°

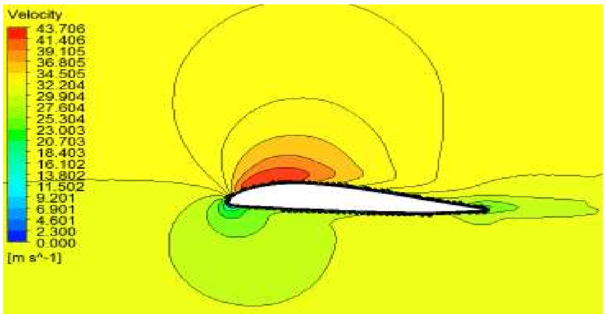




Without Winglet **With Winglet**

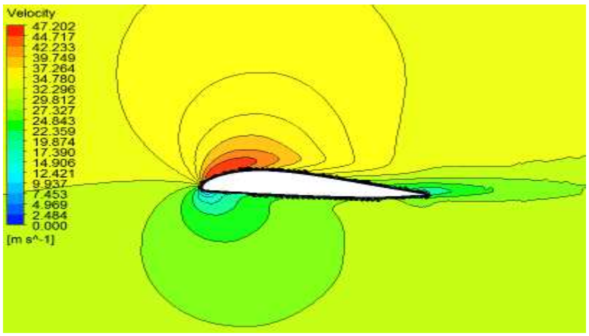
Velocity Contour at α=5°

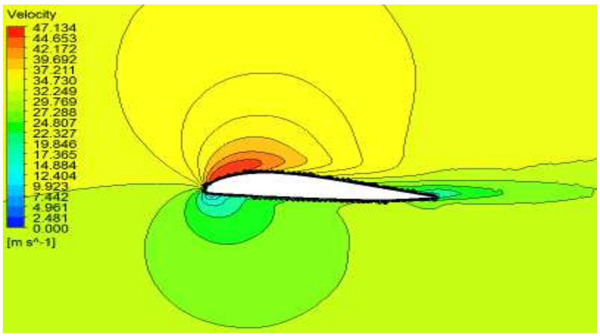




Without Winglet **With Winglet**

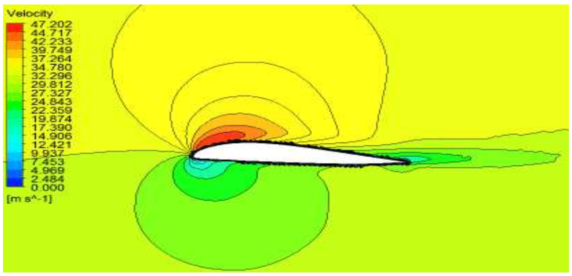
Velocity Contour at α=8°

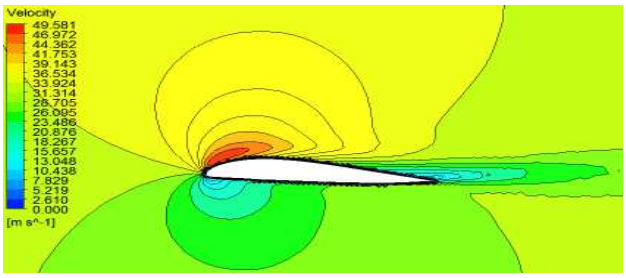




Without Winglet **With Winglet**

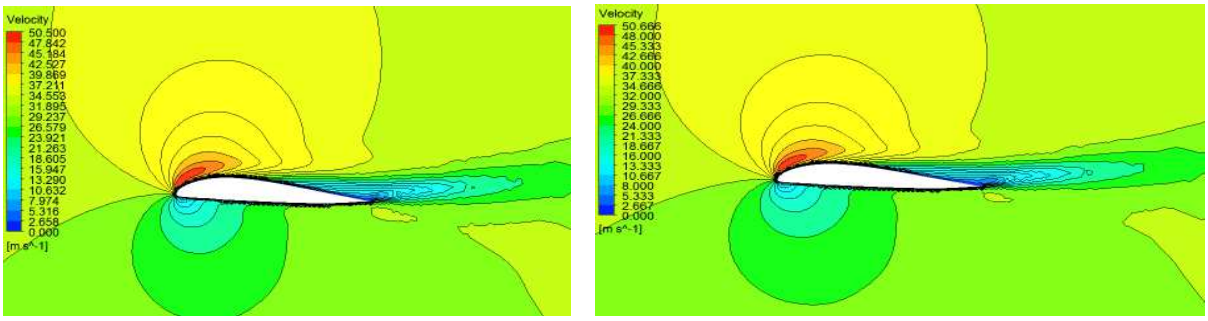
Velocity Contour at α=10°





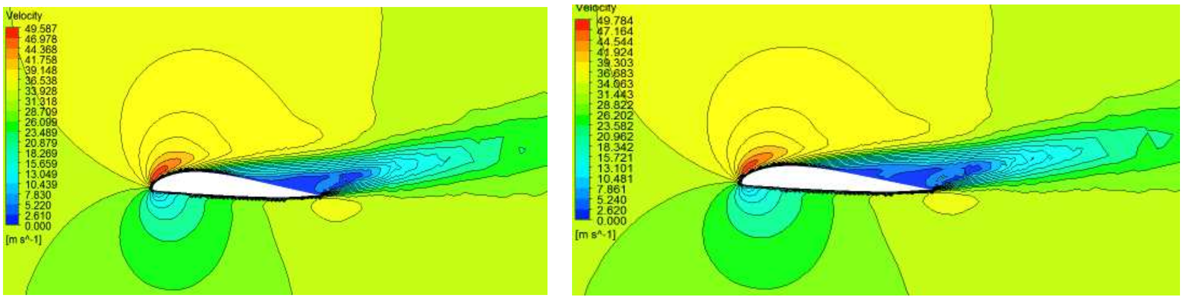
Without Winglet **With Winglet**

Velocity Contour at α=12°



Without Winglet **With Winglet**

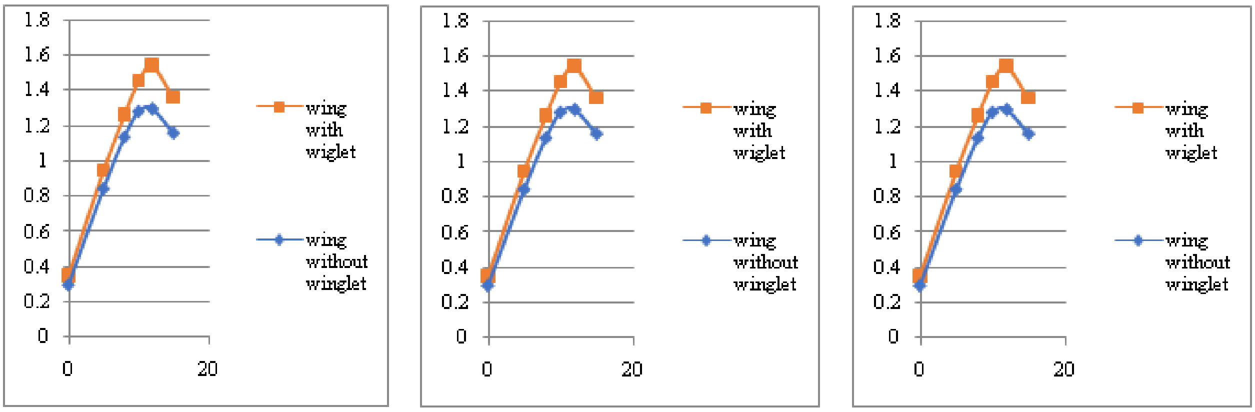
Velocity Contour at α=15°



Without Winglet **With Winglet**

Figure 3: Velocity Contours for Different Wing Configuration

Plots



Lift Coefficient Curve **Drag Coefficient Curve** **L/D Ratio Curve**

Figure 4: Various Plots for Various Wing Configurations

CONCLUSIONS

This study played a significant role in understanding the wing design for UAV aircrafts. Winglets were added to the base model to reduce the drag and to improve its overall aerodynamic efficiency. With the comparative analysis, the model II (with winglets) shows the better performance when compared with the model I. the model II design provides us the better results even in greater angle of attacks also. The analysis of wing helped in significantly predicting a better performance and reduced power consumption of the aircraft by reducing the drag and increasing lift forces.

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